Appendix B

Assumed Disposal Cell Cover Conceptual Design and Construction

B1.0 Introduction

This appendix describes the technical basis for the disposal cell cover conceptual design assumed for the purposes of this environmental impact statement (EIS) at the Moab, Klondike Flats, and Crescent Junction, Utah, sites. The design is strictly pre-conceptual and is intended to develop a basis for comparing impacts between the alternatives. This assumed design is not intended to commit the U.S. Department of Energy (DOE) to any specific cover design but rather to establish a reasonable basis for evaluating environmental impacts associated with this component of site remediation and reclamation.

The design for the White Mesa Mill site disposal cell cover is different from the design described here because it is based on an unsolicited proposal submitted to DOE. The White Mesa Mill cover approach reflects an alternative design more typical of Title II (Uranium Mill Tailings Radiation Control Act [UMTRCA]) uranium mill tailings reclamation similar to that proposed in the U.S Nuclear Regulatory Commission's (NRC's) *Final Environmental Impact Statement Related to Reclamation of the Uranium Mill Tailings at the Atlas Site, Moab, Utah* (NRC 1999). A brief description of the White Mesa Mill cover design is included in Section B4.0.

By including both design approaches, DOE has attempted to support decision-making by presenting a range of potential cover design approaches and a sense of the associated impacts related to the cover component selected for the final remedy.

B2.0 Current Design Concept

Engineered covers are the accepted remedial action to achieve containment (DOE 1989). In the case of uranium mill tailings, the engineering process must address the regulatory requirement that the cover remain effective for 1,000 years where reasonably achievable, and in no case for less than 200 years (EPA 1983).

In the semiarid Moab environment, ground water recharge is naturally limited where thick, fine-grained soils store precipitation until soil evaporation and plant transpiration seasonally return it to the atmosphere. The current assumed design mimics and enhances this natural water conservation. The design includes a water storage soil layer consisting of thick, fine-grained soil. This water storage soil layer overlies a coarse-grained capillary break layer that limits downward water movement and increases the water storage capacity of the water storage soil layer. High tensions in the small pores of the water storage soil layer impede movement of water into the larger pores of the underlying coarse-grained layer. Drainage into the capillary break layer occurs only if water accumulation at the sponge/capillary break layer interface approaches saturation and tensions decrease sufficiently for water to enter the larger pores (Ho and Webb 1998; Stormont and Morris 1998; Hillel 1980).

Evapotranspiration prevents excessive water accumulation above the textural break (Waugh et al. 1991; Anderson et al. 1993; Link et al. 1994; Sackschewsky et al. 1995; Waugh et al. 2004; Anderson and Forman 2002). In short, the water storage soil layer stores water while plants are dormant, then plants extract stored water during the growing season and return it to the atmosphere. Performance monitoring data for similar water balance designs have shown that flux rates are considerably less than 1×10^{-7} centimeters per second (cm/s) (Waugh 2004).

The assumed design relies on management of the water balance as the primary means for limiting water infiltration. Figure 2–6 of DOE's current draft EIS is a conceptual cross section of the final condition of the proposed disposal cell. The figure also illustrates the types and cover dimensions of the materials that would be placed on the sides and top of the cell to contain radon emissions and stabilize the cell. Variations of this design would be used for both the on-site and off-site alternatives analyzed in the draft EIS.

The assumed cover system's top slope**,** described from the base upward, would consist of

- A 1.5-foot-thick radon/infiltration barrier consisting of basal clay.
- A 0.5-foot-thick capillary break layer consisting of coarse sand/fine gravel.
- A 3.5-foot-thick water storage soil layer consisting of fine-grained soil.
- A 0.5-foot-thick surface erosion protection layer (called the soil/rock admixture) consisting of 80 percent soil and 20 percent limestone riprap.
- A vegetated surface for water balance control.

The assumed cover system's side slope would be identical to the top slope system with the exception of the soil/rock admixture. Because the side slope would be steep, a much greater erosion potential would exist compared to the top slope. A 1-foot-thick riprap rock surface would be designed and constructed in accordance with NUREG-1623, *Design of Erosion Protection for Long-Term Stabilization* (NRC 2002). To facilitate water-balance control, voids in the riprap would be filled with soil and planted.

Table B–1 lists the basis for each component of the assumed design.

Table B–1. Technical Basis and Assumptions for Components of the Assumed Cover Design

Compacted Soil Layer • Layer thickness would be based on calculations of radon flux at the surface of the compacted soil layer. • Soil type (e.g., clay loam) would be selected from available borrow sources that can satisfy performance requirements for permeability and radon attenuation. • Compaction requirements would be determined with tests and calculations of saturated hydraulic conductivity and radon attenuation. • Soil conditioning requirements would consider the morphology and structure of borrow soils.
Capillary Break Layer • Grain size and gradation requirements would be based on tests and calculations of (1) unsaturated flow (e.g., Richard's equation) between the water storage soil layer and capillary break layer, and (2) saturated hydraulic conductivity. • The layer thickness would be based on the design (monolayer or graded filter) and constructability.

Table B–1 (continued). Technical Basis and Assumptions for Components of the Assumed Cover Design

Water Storage Soil Layer ***Materials:*** • The soil type would be selected from available borrow sources that can satisfy water balance and revegetation performance standards. • Soil selection criteria would include soil hydraulic properties and water storage capacity. • Soil materials would have adequate fertility and nominal phytotoxicity (e.g., low salinity and sodicity) for establishing and sustaining a diverse plant community. ***Thickness*****:** The thickness would be based on evaluations of • Current and possible future climates. • Water storage capacity. • Plant evapotranspiration rates and seasonality. • Plant root ecology, depths, and distribution. • Burrowing animal ecology, habitat conditions, and burrow characteristics. • Frost protection requirements for the underlying compacted soil layer.
Soil/Rock Admixture • Rock mixed into the soil/rock admixture on the top slope and side slope would satisfy NRC criteria for size and durability. • The hydraulic properties of interstitial soil would match the underlying water storage soil layer. • The interstitial soil would be live topsoil with favorable fertility, microbiology, propagules, and nominal phytotoxicity. • The admixture layer would be placed to act as a mulch, to reduce evaporation, and to hold plant-available water near the surface. • No credit would be taken for erosion protection provided by plants.
Vegetation • Revegetation goals would include rapid establishment; ability to adapt to soil/rock admixture habitat; ample and spatially uniform evapotranspiration rates; sustainability; resilience to disturbance (e.g., fire, drought, disease); and consistency with future land use. • The revegetation design would be based on current and future climate, potential natural vegetation, and borrow soil hydrology, chemistry, fertility, and biology.

B3.0 Construction

After all the contaminated materials from the site and vicinity properties were relocated to the top of the tailings pile and the consolidation process was under way, the final side slope would be graded and recontoured to a 3:1 horizontal:vertical slope. The top would be contoured to slope (less than 0.5 percent) outward toward the side slopes.

B3.1 Side Slope Construction

Side slope cover construction would start with placement of the compacted soil layer that would form the radon barrier. Clayey soil borrow material would be transported to the site by truck or tandem trailers, dumped at the base of the pile, and pushed up the recontoured slopes with a dozer. A similar procedure would be used to place the capillary break layer’s sand/gravels and the water storage soil layer’s fine-grained soils. The soil/rock admixture would be the final layer placed on the side slopes. For this layer, erosion control limestone riprap would be placed to the required thickness, and interstitial voids would be loosely filled with soils.

B3.2 Top Slope Construction

Top slope cover construction would begin when pore pressure readings indicated that the slimes were 90 percent consolidated. Construction would follow the same order as side slope construction described above. A surface layer consisting of a soil/rock admixture 0.5 foot thick would protect the underlying layers from the effects of erosion. This layer would be constructed by creating a 20 percent–80 percent mixture of rock-soil by volume. Rock would be sized to resist wind and water erosion. Soil would promote plant growth, which is crucial for a successful water-balance cover. The soil/rock admixture would be planted with vegetation for water extraction and infiltration control.

B3.3 Construction-Related Features and Objectives

B3.3.1 Vegetation

A diverse mixture of native plants on the cover would maximize water removal by evapotranspiration (Link et al. 1994) and remain more resilient to major disturbances and fluctuations in the environment. Revegetation efforts would attempt to emulate the structure, diversity, dynamics, and function of native plant communities occurring on deep, fine-grained soils in the area. The native vegetation at Moab is a mosaic of species that structurally and functionally change in response to disturbances and climatic fluctuations (Tausch et al. 1993). Similarly, biological diversity in the cover vegetation would be important to plant community stability and resilience, given variable and unpredictable changes in the environment resulting from pest outbreaks, disturbances (overgrazing, fire, etc.), and climatic fluctuations.

B3.3.2 Erosion Control

A primary erosion control issue for vegetated cover designs is whether vegetation alone adequately limits soil loss or if gravel and rock admixtures are necessary to armor the soil when vegetation is sparse or less dependable. Vegetation and organic litter disperse raindrop energy, slow flow velocity, bind soil particles, filter sediment from runoff, increase infiltration, and reduce surface wind velocity (Wischmeier and Smith 1978). However, vegetation alone may be inadequate, particularly in the first years after construction. To achieve the benefits of a combination of rock for erosion protection and plants for evapotranspiration, DOE's assumed cover design includes mixing rock into the upper soil layer. Erosion studies (Finely et al. 1985; Ligotke 1994) and soil-water balance studies (Waugh et al. 1994; Sackschewsky et al. 1995) suggest that rock mixed into the cover topsoil would control both water and wind erosion and act as a mulch to enhance plant establishment and growth. As wind and water passed over the surface, some winnowing of fines from the admixture would be expected, leaving a vegetated erosion-resistant pavement.

B3.3.3 Frost Protection

The 3.5-foot-thick water storage soil layer would provide more than adequate depth to isolate the capillary break layer and compacted soil layer from frost damage. The estimated maximum frost depth in the topsoil layer would be less than 3 feet given historical climatic conditions. A modified Berggren approach (DOE 1989; Smith and Rager 2002) would be used to calculate the maximum frost depth for a range of possible future climate changes.

B3.3.4 Biointrusion Control

The current assumed design includes measures to limit biological intrusion by plant roots and burrowing vertebrates. By retaining soil water close to the surface, the water storage soil layer and capillary break layer would create a habitat for relatively shallow-rooted plant species; root growth would generally be limited to regions within the soil where extractable water was available. The thickness of the water storage soil layer is expected to exceed the burrow depths of most vertebrates in the Moab area. If deeper burrowing were likely for either current conditions or for a future climate scenario, a layer of rock would be mixed into the water storage soil layer as an added deterrent. Loosely aggregated gravel and rock have been shown to deter burrowing mammals (Cline et al. 1980; Hakonson 1986; Bowerman and Redente 1998). A rock biointrusion layer would be placed immediately above the capillary break layer.

B4.0 White Mesa Mill Site Disposal Cell Cover

The White Mesa Mill site cover design consists of an erosion-protection layer consisting of 3-inch-diameter riprap, a 2-foot frost barrier, a 12-inch compacted clay radon barrier, and 3 feet of platform fill. Side slopes would consist of random fill covered by riprap. The cover design is consistent with other Title II cell designs approved by NRC. DOE has determined that at the conceptual stage, the design appears to be reasonable.

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